UNIVERSAL SNAP-FIT SPACER

FIELD OF THE INVENTION

The present invention relates to the interconnection of circuit boards. In particular, the present invention relates to a universal snap-fit spacer system for stacking circuit boards, including circuit boards of different thicknesses.

BACKGROUND OF THE INVENTION

Electrical and electronic circuits are often formed on planar circuit boards. Often, it is desirable to interconnect two or more circuit boards to one another in a stacked configuration. When stacking multiple circuit boards, a minimum spacing must be maintained between a first circuit board and the circuit board or boards adjacent to the first circuit board. Such spacing is required for various reasons, including the prevention of electrical shorts between the boards, and the provision of cooling airflow over components interconnected to the circuit boards.

Systems for interconnecting circuit boards include threaded fasteners in combination with spacers. In such a system, a screw (or bolt) is passed through a hole formed in a first circuit board. Next, the spacer is placed over the screw, before the end of the screw is passed through a hole formed in a second circuit board. Finally, a nut is placed over the end of the threaded fastener to secure the assembly. Although a system of threaded fasteners in combination with spacers is capable of securely fastening a first circuit board to a second circuit board, such a system is not entirely satisfactory for a variety of reasons. For instance, considerable labor is involved in piecing together and

securing the assembly, thus resulting in a relatively slow and expensive assembly process.

In addition, in order to interconnect a third circuit board using such a system, additional holes must be formed in either the first or second circuit board. This is disadvantageous, as space on individual circuit boards is often at a premium. In addition, the assembly of an electrical component having more than two interconnected circuit boards creates additional assembly difficulties, as access to the fasteners used to interconnect additional circuit boards is often limited. Alternatively, stacks of three or more circuit boards may be created by interposing interior circuit boards between two spacers, and using a screw that passes through all of the circuit boards. However, the assembly process for stacking three or more circuit boards in this manner is even more difficult than stacking a pair of circuit boards.

Another system for interconnecting multiple circuit boards involves the use of threaded spacer members in connection with threaded screws (or bolts). In such a system, the screw is placed through a hole formed in a first circuit board, and is then threaded into the threaded spacer. Next, a second screw or bolt is placed through a hole in the second circuit board, and is then threaded into the opposite end of the threaded spacer. Although such a system can decrease assembly times as compared to systems using spacers having smooth bores in combination with threaded fasteners, the threading of multiple components to one another is still required. Accordingly, the interconnection of multiple circuit boards using such a system remains relatively time consuming and expensive. In addition, such a system may also require the use of additional holes in circuit boards where more than two circuit boards are attached to one another.

Snap-fit, one piece interconnects have also been used for interconnecting circuit boards. Such one piece interconnects are capable of reducing the time required to interconnect multiple circuit boards. However, such one piece interconnects must be supplied in a variety of sizes, to accommodate different circuit board thicknesses and to accommodate different spacings between interconnected circuit boards. In addition, where more than two circuit boards are interconnected, interior circuit boards must have an additional set of holes formed therein, limiting the area of the circuit board available for electrical componentry

For the reasons set forth above, there is a need for a method and apparatus for interconnecting multiple circuit boards quickly and inexpensively. In addition, there is a need for a method and apparatus that allows for more than two circuit boards to be interconnected that requires a minimal amount of circuit board area. There also is a need for a method and apparatus for interconnecting multiple circuit boards that is reliable in operation and inexpensive to implement.

SUMMARY OF THE INVENTION

The present invention is directed to solving these and other problems and disadvantages of the prior art. According to the present invention, a spacer element and a fastener member are provided for interconnecting multiple circuit boards. In operation, a first fastener member is used to interconnect a first circuit board to a spacer element. A second fastener member is then used to interconnect a second circuit board to the spacer element. The interconnections between the circuit board and the fastener member, and between the spacer element and the fastener member are made by a locking assembly

provided on either end of the fastener member that allows the fastener member to be snapped together with the spacer element and with a circuit board or a second spacer element.

In accordance with an embodiment of the present invention, the locking assembly of the fastener member comprises a plurality of adjacent locking members interconnected to the body of the fastener member by a resilient portion. The resilient portion biases the locking members such that in a nominal position the distance between the outer edge of a first locking member and the outer edge of a second locking member adjacent to the first locking member is a first amount. When a force sufficient to overcome the biasing force is presented in a direction tending to draw adjacent locking members towards one another, the distance between the outer edge of the first locking member to the outer edge of the second locking member can be reduced to a second amount, that is less than the first amount.

In accordance with an embodiment of the present invention, the surface of the locking member proximate to the ends of the fastener member may be angled, to present a camming surface. Thus, when the fastener members are pressed into a hole having a diameter that is about equal to or slightly greater than the second distance, the locking members are pressed towards one another and the fastener can be inserted into the hole.

The biasing force provided by the resilient portion of the fastening member causes the distance between the outer edges of the locking members to return to the first or nominal amount after the locking members have passed through the hole, or have reached a recess in the interior of the spacer element. The surface of the locking members

adjacent to the body portion of the fastener member may be perpendicular to the longitudinal axis of the fastening member, to form a locking surface that prevents the fastener member from being removed from the hole once the resilient members have returned the locking members to their nominal position. In a typical assemblage, a first fastener member is used to secure a first circuit board to a spacer element, while a second fastener member is used to interconnect a second circuit board to the spacer element.

In accordance with an embodiment of the present invention, the spacer element has an interior bore diameter about equal to the distance between the outer edges of the locking members when the locking members are compressed. Along the interior bore, multiple recesses may be formed. These recesses may be spaced at predetermined intervals, allowing a fastener member to be locked at varying depths within the spacer element.

According to still another embodiment of the present invention, depth control holes may be formed in the spacer element that intersect the interior bore and that are transverse to the longitudinal axis of the spacer element. Depth control rods may then be inserted in the depth control holes to prevent fastener members from being inserted into the spacer element further than the position of the depth control rod.

According to an embodiment of the present invention, multiple circuit boards may be interconnected to one another. In such an embodiment, a first fastener member is inserted into a hole formed in a first circuit board. A first end of the fastener member may be inserted into a first spacer element, and a second end of the fastener member may be inserted into a second spacer element such that the circuit board is held between the

two spacer elements. A second circuit board may then be interconnected to the first spacer element by inserting a second fastener member into a hole in the second circuit board, and by inserting the second fastener member into an end of the first spacer element opposite the first fastener member. Similarly, a third circuit board may be stacked with the first two circuit boards by inserting a third fastener member through a hole in the third circuit board, and by inserting the third fastener member into an end of the second spacer element opposite the first fastener member.

According to yet another embodiment of the present invention, different thicknesses of circuit boards may be accommodated by a single fastener member and spacer element combination. For instance, a first circuit board thickness may be accommodated by inserting the fastener member into the spacer element up to a first depth, while a second circuit board thickness may be accommodated by inserting the fastener member into the spacer element up to a second depth. According to still another embodiment of the present invention, spacer members may be used in combination with spacer elements to accommodate different circuit board thicknesses.

These and other advantages and features of the invention will become more apparent from the following description of illustrative embodiments of the invention, taken together with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an exploded perspective view of a universal snap-fit spacer system in accordance with an embodiment of the present invention;

Fig. 2A is an elevational view of the universal snap-fit spacing system of **Fig. 1** interconnecting first and second circuit boards;

Fig. 2B is a cross-sectional view taken along section line A-A of **Fig. 2A**;

Fig. 2C is a cross-sectional view of the universal snap-fit spacing system of **Fig. 1** with a fastener member partially inserted in a spacer element;

Fig. 3A is an elevational view of a universal snap-fit spacer system in accordance with an embodiment of the present invention, interconnecting first, second and third circuit boards;

Fig. 3B is a cross-sectional view taken along section line B-B of **Fig. 3A**;

Fig. 4A is an elevational view of a universal snap-fit spacer system in accordance with an embodiment of the present invention, interconnecting a first circuit board having a first thickness and a second circuit board having a second thickness; and

Fig. 4B is a cross-sectional view taken along section line C-C of **Fig. 4A**.

DETAILED DESCRIPTION

With reference now to **Fig. 1**, various components of a universal snap-fit spacer system **100** are illustrated. In general, the system **100** includes a fastener member **104** and a spacer element **108**. In **Fig. 1**, two fastener members **104a** and **104b** are illustrated.

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The fastener member **104** generally includes a body portion **110**, and a resilient portion **112**. A locking assembly **116** is interconnected to the body portion **108** 110 of the fastener member **104** by the resilient portion **112**. In the embodiment of the fastener member **104** illustrated in **Fig. 1**, a locking assembly **116** is formed at each end of the fastening member **104**. According to the embodiment illustrated in **Fig. 1**, each locking

assembly **116** includes a pair of locking members **120** that comprise a camming surface **124** and a locking surface **128**. In general, the locking members **120** are interconnected to the body portion **110** of the fastener member **104** by a pair of stem members **132** that comprise the resilient portion **112**. A gap **136** is formed between the stem members **132**.

The spacer element **108** comprises a cylindrical member **144** with an interior bore **148** formed concentrically with the longitudinal axis of the cylindrical member **144**. Depth control holes **152** are formed through the cylindrical member **144**, such that they are transverse to the longitudinal axis of the cylindrical member **144** and intersect the interior bore **148**. Exterior grooves **156** may be formed about the circumference of the cylindrical member **144** at predetermined intervals. Depth control rods **160**, sized to be received by the depth control holes **152** may also be provided as part of the system **100**. According to an embodiment of the present invention, the depth control rods are held in the depth control holes **152** by friction.

When no external force is applied to the locking assembly **116**, the locking assembly **116** is in a first or nominal state. In this first state, the distance between the outer extent of a pair of locking surfaces **128** is a first, or maximum amount (*e.g.*, as illustrated in **Fig. 1**). The distance across the outer extent of the locking surfaces **128** may be reduced to a second, minimal amount, by providing a force that brings the pair of locking members **120** together, closing the gap **136** at an end of the fastener member **104**. In general, the edges of the camming surfaces **124** opposite the locking surfaces **128** present a maximum diameter that is less than the diameter of the bore **148**. As the locking members **120** are pressed into the interior bore **148**, the camming surfaces **124**

force the locking members **120** together, across the gap **136**. Thus, the gap **136** allows the maximum distance across the locking members **120** to be about equal to the diameter of the interior bore **148**. Accordingly, the fastener member **104** is free to enter the spacer element **108**. When a first recess, such as recess **208a** (see **Fig. 2B**), is encountered, the biasing force provided by the resilient portion **112** causes the locking members **120b** to return to their nominal position. In this nominal position, the locking members **120** present a maximum diameter, and the locking edge **140** of the locking members **120** is engaged with the latching surface **216** (see **Fig. 2B**) of the recess **208**. Accordingly, the fastener member **104** is prevented from being withdrawn from the spacer element **108**. If engagement with a next recess (e.g., recess **208b**) is desired, the fastener member **104a** can be pressed further into the spacer element **108**. Forcing the fastener member **104** further into the spacer element **108** causes the tapered surface **212** of the recess **208** to act on the camming surface **124** of the locking members **120**, bringing the locking members **120** closer together across the gap **136**. Accordingly, it can be appreciated that the fastener member **104** can be moved further into the spacer element **108** to engage a next recess, but cannot be withdrawn from the interior bore **148** of the spacer element **108** after a first recess **208** has been engaged.

With reference now to **Fig. 2A**, first **200a** and second **200b** circuit boards, held together by a snap-fit spacer system **100** in accordance with an embodiment of the present invention are illustrated. From **Fig. 2A**, it can be appreciated that the first circuit board **200a** is held between the locking assembly **116** at an end of a first fastener member **104a** and a first end of the spacer element **108**. Furthermore, it is apparent that the second

circuit board **200b** is held between the locking assembly **116** at an end of a second fastener member **104b** and the second end of the spacer element **108**.

With reference now to **Fig. 2B**, the spacer system **100** and circuit boards **200a-b** are shown in cross-section, the cross-section being taken along section line A-A in **Fig. 2A**. In **Fig. 2B**, the interior features of the spacer element **108** are clearly illustrated. In particular, annular recesses **208** formed within the interior bore **148b** are visible. In general, the recesses **208** have a maximum diameter that is about equal to or greater than the maximum distance between the edges of the locking surfaces **128** when the locking assembly **116** is in the nominal position. As shown in **Fig. 2B**, the recesses **208** may include tapered surfaces **212** on a side of the recesses **208** proximal to the center of the spacer element **108** to assist the camming surfaces **124** in forcing the pair of locking members **120** towards one another, allowing the fastener members **104** to be pushed towards a recess **208** deeper within the interior bore **148**. A latching surface **216** may be formed perpendicular to the longitudinal axis of the interior bore **148** and on a side of the recess proximal to the nearest end of the spacer element **108**.

With reference now to **Fig. 2C**, a first fastener member **104a** is shown being inserted into a spacer element **108**. As illustrated in **Fig. 2C**, the camming surfaces **124** force the stem members **132** towards one another, closing or reducing the gap **136** at the end of the fastener member **104a** as the fastener member is inserted into the hole **202a** in the circuit board **200a** or the interior bore **148** of the spacer element **108**. With the stem members **132** forced together, the distance across the opposite locking surfaces **128** of the locking assembly **116** is reduced to an amount about equal to the diameter of the hole

202a or of the interior bore **148**.

In **Fig. 2B**, the fastener members **104** are each shown with the locking surfaces **128** of a locking assembly **116** engaged with the latching surface **216** of recesses **208**. Therefore, it is apparent that the locking assembly **116** at a first end of the first fastener member **104a** was pushed past the first **208a** and second **208b** recesses before coming into engagement with the third recess **208c**. It will further be noted that the locking surfaces **128** of the locking members **120** are engaged with the latching surface **216** of the third recess **208c**. This engagement prevents the fastener member **104a** from being withdrawn from the spacer element **108**. Depth control rods **160a,b** can be seen in position in depth control holes **152**. The first depth control rod **160a** prevents the first fastener member **104a** from being pushed past the third recess **208c**, and the second depth control rod **160b** prevents the second fastener member **104b** from being pushed past the fourth recess **208d**.

At a second end of the first fastener member **104a**, the locking assembly **116** can be seen in engagement with a surface of the first circuit board **200a**. In particular, the locking surfaces **128** of the locking members **120** at the second end of the first fastener member **104a** hold the first circuit board **200a** against the first end of the spacer element **108**. Likewise, at the second end of the spacer element **108**, the second fastener member **104b** affixes the second circuit board **200b** against the spacer element **108**. The locking members **120** at the first end of the second fastener member **104b** can be seen in engagement with a fourth recess **208d**. In order to position the locking members **120** of the first end of the second fastener member **104b** in that recess **208d**, fifth **208e** and sixth

208f recesses were passed. In general, the recesses **208d,e**, and **f** are the mirror images of **208a, b** and **c**. In particular, the recesses **208d, e** and **f** have tapered surfaces **212** oriented to cooperate with the camming surfaces **124** in reducing the effective diameter of the locking members **120** of fastener members **104** inserted into the second end of the spacer element **108**, for example while the fastener member **104b** is being brought into engagement with the fourth recess **208d**, as explained above.

With reference now to **Fig. 3A**, the fastening system **100** of the present invention is shown in an additional embodiment, interconnecting three circuit boards **300, 300a** and **300b** together in a stacked relationship. In particular, a first spacer element **108a** is interposed between the first **300a** and second **300b** circuit boards, while a second spacer element **108b** is interposed between the second **300b** and third **300c** circuit boards. In addition, a spacer member **304** is shown interposed between a second end of the first spacer element **108a** and the second circuit board **300b**.

With reference to **Fig. 3B**, it can be appreciated that the depth control rod **160** inserted in the depth control hole **152a** of the second spacer element **108b** is useful to prevent the second fastener member **104b** from passing the first recess **208g** of the second spacer element **108b** to engage a recess **208h** or **208i** deeper within the second spacer element **108b**. Accordingly, the fastener member **104b** can be inserted in the second spacer element **108b**, through the second circuit board **300b**, through the spacer member **304**, and in the first spacer element **108a**, without causing the second fastener member **104b** to travel too deeply into the second spacer element **108b**. Furthermore, it can be appreciated that if a depth control rod **160** is inserted in the depth control hole **152a** of the

first spacer element **108a**, the order of assembly of the interconnection between the first **108a** and second **108b** spacer elements, the second circuit board **304** and the spacer member **312** is not important. Without a depth control rod in the depth control hole **152a** of the first spacer element, the second fastener member should first be inserted in the second spacer element **108b**, through the circuit board **300b**, through the spacer member **304**, and finally inserted in the first spacer element **108a**.

With reference now to **Fig. 4A**, the fastening system **100** of the present invention is shown in yet another embodiment, interconnecting a first circuit board **400a** having a first thickness, to a second circuit board **400b** having a second thickness.

With reference now to **Fig. 4B**, the fastening system **100** illustrated in **Fig. 4A** is shown in a cross-sectional view taken along section line C-C. In **Fig. 4B**, the first fastening member **104a** can be seen with a first locking assembly **116a** engaged with the third recess **208c** of the spacer element **108**. This configuration allows the second locking assembly **116b** to hold the first circuit board **400a** between the locking surfaces **128** of the second locking assembly **116b** and the first end of the spacer element **108**. The second fastener member **104b** can be seen with a first locking assembly **116c** engaged with a sixth recess **208f**. The locking assembly **116d** at a second end of the second fastener member **104b** holds the second circuit board **400b** against the second end of the spacer element **108**. Accordingly, as illustrated in **Fig. 4B**, by engaging different recesses **208**, along the interior bore **148** of the spacer element **108** with a locking assembly **116** of a fastener member **104**, the system **100** of the present invention is capable of interconnecting circuit boards **400** of different thicknesses to one another in a stacked

relationship.

As an illustration of how the fastener members **104** and spacer elements **108** may be dimensioned in a system **100**, the following is provided as an example. However, it should be appreciated that other spacings and relationships may be used. In general, fastener members **104** and spacer elements **108** should be dimensioned to accommodate the thickness of circuit boards that the system **100** is likely to be used to interconnect. According to this example, the recesses **208** adopted for receiving the locking members **120** of a fastener member **104** inserted in an end of a spacer element **108** are spaced apart from one another by a distance x. The distance from an end of the spacer element **108** to the latching surface **216** of the recess **208** nearest that end of the spacer element **108** is equal to x less the thickness of the thickest circuit board of those circuit boards having a thickness y that is less than x adapted for interconnection using the system **100**. Furthermore, the distance between the locking surfaces **128** of opposite locking assemblies or a fastener member **104** is equal to 3 x. Accordingly, as shown in **Fig. 1B**, a circuit board having a thickness y at an end of a stack of circuit boards, can be interconnected to a spacer element **108** by inserting a fastener member **104** through a hole in the circuit board into the interior bore **148** of the spacer element **108** such that the third recess (e.g., recess **208c**) is engaged by the locking members **120** at a first end of the fastener member **104**. As a further example, as shown in **Fig. 4B**, a circuit board **400b** having a thickness equal to y + 2x can be interconnected to another circuit board **400a** using a fastener member **104b** inserted through the second circuit board **400b** and engaged with the sixth recess **208f**.

Where a circuit board is to be stacked such that it is positioned between two other circuit boards, as illustrated in **Figs. 3A** and **3B**, a spacer member **304** having a thickness y is provided such that the distance between recesses at the second end of the first spacer element **108a** is an integer multiple of the distance x from the recesses at the first end of the second spacer element **108b**.

If a spacer element **108** having a shorter length is desired, it can be cut at a groove **156**. Each groove **156** is positioned so that it lies in or near a plane that includes a latching surface **216** of a recess **208**.

In accordance with an embodiment of the present invention, the components (*e.g.*, fastener member **104**, spacer element **108** and depth control rods **160**) are formed from nonconductive materials. For example, the components of the present invention may be formed from nylon, polypropylene or plastic. In accordance with yet another embodiment of the present invention, only the spacer element **108** is formed from non-conductive materials. Where the conduction of electricity between interconnected circuit boards is not a required or desired characteristic, the spacer element **108** may be formed from a conductive material.

Although the above description discusses the interconnection of circuit boards, the invention is not so limited. For example, the present invention may be utilized whenever a flexible system for quickly interconnecting components is desired. In addition, it should be appreciated that the present invention may be used to interconnect circuit boards to assemblies or components other than additional circuit boards. For example, the present invention may be used to interconnect a circuit board to an enclosure.

The foregoing discussion of the invention has been presented for purposes of illustration and description. Further, the description is not intended to limit the invention to the form disclosed herein. Consequently, variations and modifications commensurate with the above teachings, within the skill and knowledge of the relevant art, are within the scope of the present invention. The embodiments described hereinabove are further intended to explain the best mode presently known of practicing the invention and to enable others skilled in the art to utilize the invention in such or in other embodiments and with various modifications required by their particular application or use of the invention. It is intended that the appended claims be construed to include the alternative embodiments to the extent permitted by the prior art.